Listing of Claims

What is claimed is:

1. (Currently Amended) A method of producing hydrogen comprising:

reacting a first portion of particles of a hydride with ~~a chemically equivalent quantity of~~ water to produce heat in a first reaction and reacting, in the solid-state, a mixture of a second portion of particles of said hydride and particles of a hydroxide in a second reaction, by transferring said heat thereto.

2. (Original) The method according to claim 1 wherein said second reaction produces hydrogen.

3. (Original) The method according to claim 1 wherein said first reaction produces at least a portion of said hydroxide.

4. (Original) The method according to claim 1 wherein said second reaction commences while said first reaction is occurring.

5. (Original) The method according to claim 1 wherein said second reaction is exothermic.

6. (Original) The method according to claim 1 wherein said second reaction producing hydrogen is endothermic.

7. (Original) The method according to claim 1 wherein said water is added to said hydride.

8. (Original) The method according to claim 7 wherein said amount of heat generated is greater than or equal to an activation energy of said second reaction.

9. (Original) The method according to claim 8 wherein said second reaction proceeds to substantial completion and said second portion of hydride is substantially consumed in said second reaction.

10. (Original) The method according to claim 1 wherein said hydride is represented by the formula: $MI^{x}H_{x}$, where MI represents one or more cationic species other than hydrogen and x represents an average valence state of MI.

11. (Original) The method according to claim 1 wherein said hydroxide is represented by the formula: $MII^{y}(OH)_{y}$, where MII represents one or more cationic species other than hydrogen and y represents an average valence state of MII.

12. (Original) The method of claim 1 wherein said hydride is represented by $MI^{x}H_{x}$ and said hydroxide is represented by $MII^{y}(OH)_{y}$, where MI and MII respectively represent one or more cationic species other than hydrogen, and x and y represent average valence states of MI and MII, respectively.

13. (Withdrawn) The method of claim 1 wherein MI and MII comprise one or more distinct cationic species.

14. (Original) The method of claim 1 wherein MI and MII comprise one or more of the same cationic species.

15. (Original) The method of claim 1 wherein MI or MII is a complex cationic species comprising two distinct cationic species.

16. (Original) The method of claim 1 wherein MI is selected from the group consisting of CH_3, Al, As, B, Ba, Be, Ca, Cd, Ce, Cs, Cu, Eu, Fe, Ga, Gd, Ge, Hf, Hg, In, K, La, Li, Mg, Mn, Na, Nd, Ni, Pb, Pr, Rb, Sb, Sc, Se, Si, Sm, Sn, Sr, Th, Ti, Tl, V, W, Y, Yb, Zn, Zr, and mixtures thereof.

17. (Original) The method of claim 1 wherein MII is selected from the group consisting of CH_3, C_2H_5, C_3H_7, Al, As, B, Ba, Be, Ca, Cd, Ce, Cs, Cu, Eu, Fe, Ga, Gd, Ge, Hf, Hg, In, K, La, Li, Mg, Mn, Na, Nd, Ni, Pb, Pr, Rb, Sb, Sc, Se, Si, Sm, Sn, Sr, Th, Ti, Tl, V, W, Y, Yb, Zn, Zr, and mixtures thereof.

18. (Original) The method of claim 12 wherein MI and MII are each elements independently selected from the group consisting of Al, B, Be, Ca, K, Li, Mg, Na, Sr, Ti, and mixtures thereof.

19. (Original) The method of claim 12 wherein said hydroxide further comprises: $MII^y(OH)_y \cdot wH_2O$, where MII represents said one or more cationic species other than hydrogen, y represents an average valence state of MII, and w represents a stoichiometric amount of hydrated water.

20. (Original) The method according to claim 1 wherein said hydroxide is represented by the formula: $MII^y(OH)_y \cdot wH_2O$, where MII represents said one or more cationic species other than hydrogen, y represents an average valence state of MII, and w represents a stoichiometric amount of hydrated water.

21. (Original) The method of claim 1 wherein said hydride is represented by MI^xH_x and said hydroxide is represented by $MII^y(OH)_y \cdot wH_2O$, where MII represents said one or more cationic species other than hydrogen, y represents an average valence state of MII, and w represents a stoichiometric amount of hydrated water.

22. (Original) The method of claim 21 wherein MI is selected from the group consisting of Al, As, B, Ba, Be, Ca, Cd, Ce, Cs, Cu, Eu, Fe, Ga, Gd, Ge, Hf, Hg, In, K, La, Li, Mg, Mn, Na, Nd, Ni, Pb, Pr, Rb, Sb, Sc, Se, Si, Sm, Sn, Sr, Th, Ti, Tl, V, W, Y, Yb, Zn, Zr, and mixtures thereof.

23. (Original) The method of claim 21 wherein MII is selected from the group consisting of Al, As, B, Ba, Be, Ca, Cd, Ce, Cs, Cu, Eu, Fe, Ga, Gd, Ge, Hf, Hg, In, K, La, Li,

Mg, Mn, Na, Nd, Ni, Pb, Pr, Rb, Sb, Sc, Se, Si, Sm, Sn, Sr, Th, Ti, Tl, V, W, Y, Yb, Zn, Zr, and mixtures thereof.

24. (Original) The method of claim 21 wherein Ml and MII are each elements independently selected from the group consisting of Al, B, Ba, Be, Ca, Cs, K, Li, Mg, Na, Rb, Si, Sr, Ti, V and mixtures thereof.

25. (Original) The method of claim 21 wherein Ml and MII are each elements independently selected from the group consisting of Al, B, Be, Ca, K, Li, Mg, Na, Sr, Ti, and mixtures thereof.

26. (Original) The method according to claim 1 wherein said hydride is selected from the group consisting of: lithium hydride (LiH), sodium hydride (NaH), potassium hydride (KH), beryllium hydride (BeH_2), magnesium hydride (MgH_2), calcium hydride (CaH_2), strontium hydride (SrH_2), titanium hydride (TiH_2), aluminum hydride (AlH_3), boron hydride (BH_3), lithium borohydride ($LiBH_4$), sodium borohydride ($NaBH_4$), magnesium borohydride ($Mg(BH_4)_2$), calcium borohydride ($Ca(BH_4)_2$), lithium alanate ($LiAlH_4$), sodium alanate ($NaAlH_4$), magnesium alanate ($Mg(AlH_4)_2$), calcium alanate ($Ca(AlH_4)_2$), and mixtures thereof.

27. (Original) The method according to claim 1 wherein said hydroxide is selected from the group consisting of: composition is selected from the group consisting of: lithium hydroxide (LiOH), sodium hydroxide (NaOH), potassium hydroxide (KOH), beryllium hydroxide ($Be(OH)_2$), magnesium hydroxide ($Mg(OH)_2$), calcium hydroxide ($Ca(OH)_2$), strontium hydroxide ($Sr(OH)_2$), titanium hydroxide ($Ti(OH)_2$), aluminum hydroxide ($Al(OH)_3$), boron hydroxide ($B(OH)_3$) and mixtures thereof.

28. (Original) The method according to claim 1 wherein said hydride comprises LiH and said hydroxide comprises LiOH.

29. (Original) The method according to claim 28 wherein said second reaction proceeds according to a reaction mechanism of $LiH + LiOH \rightarrow Li_2O + H_2$.

30. (Withdrawn) The method according to claim 1 wherein said hydride comprises NaH and said hydroxide comprises LiOH.

31. (Withdrawn) The method according to claim 30 wherein said second reaction proceeds according to a reaction mechanism of $NaH + LiOH \rightarrow \frac{1}{2} Li_2O + \frac{1}{2} Na_2O + H_2$.

32. (Withdrawn) The method according to claim 1 wherein said hydride comprises MgH_2 and said hydroxide comprises $Mg(OH)_2$.

33. (Withdrawn) The method according to claim 32 wherein said second reaction proceeds according to a reaction mechanism of $MgH_2 + Mg(OH)_2 \rightarrow MgO + 2\ H_2$.

34. (Withdrawn) The method according to claim 1 wherein said hydride comprises AlH_3 and said hydroxide comprises $Al(OH)_3$.

35. (Withdrawn) The method according to claim 34 wherein said second reaction proceeds according to a reaction mechanism of $AlH_3 + Al(OH)_3 \rightarrow Al_2O_3 + 3H_2$.

36. (Withdrawn) The method according to claim 1 wherein said hydride comprises CaH_2 and said hydroxide comprises $Ca(OH)_2$.

37. (Withdrawn) The method according to claim 36 wherein said second reaction proceeds according to a reaction mechanism of $CaH_2 + Ca(OH)_2 \rightarrow CaO + 2\ H_2$.

38. (Withdrawn) The method according to claim 1 wherein said hydride comprises SrH_2 and said hydroxide comprises $Sr(OH)_2$.

39. (Withdrawn) The method according to claim 38 wherein said second reaction proceeds according to a reaction mechanism of $SrH_2 + Sr(OH)_2 \rightarrow SrO + 2\ H_2$.

40. (Withdrawn) The method according to claim 1 wherein said hydride comprises BH_3 and said hydroxide comprises $B(OH)_3$.

41. (Withdrawn) The method according to claim 40 wherein said second reaction proceeds according to a reaction mechanism of $BH_3 + B(OH)_3 \rightarrow B_2O_3 + 3\ H_2$.

42. (Withdrawn) The method according to claim 1 wherein said hydride comprises BeH_2 and said hydroxide comprises $Be(OH)_2$.

43. (Withdrawn) The method according to claim 42 wherein said second reaction proceeds according to a reaction mechanism of $BeH_2 + Be(OH)_2 \rightarrow BeO + 2\ H_2$.

44. (Withdrawn) The method according to claim 1 where said hydride comprises $LiBH_4$ and said hydroxide comprises $B(OH)_3$.

45. (Withdrawn) The method according to claim 44 where said second reaction proceeds according to a reaction mechanism of $3LiH + H_3BO_3 \rightarrow LiBO_2 + Li_2O + 3H_2$.

46. (Withdrawn) The method according to claim 44 where said second reaction proceeds according to a reaction mechanism of $3LiH + H_3BO_3 \rightarrow Li_3BO_3 + 3H_2$.

47. (Withdrawn) The method according to claim 44 where said second reaction proceeds according to a reaction mechanism of $3\ LiBH_4 + 4\ H_3BO_3 \rightarrow Li_3B_7O_{12} + 12\ H_2$.

48. (Original) The method according to claim 1 where said hydride comprises $LiBH_4$ and said hydroxide comprises LiOH.

49. (Original) The method according to claim 48 where said second reaction proceeds according to a reaction mechanism of $LiBH_4 + 4\ LiOH \rightarrow LiBO_2 + 2\ Li_2O + 4H_2$.

50. (Withdrawn) The method according to claim 1 where said hydride comprises $NaBH_4$ and said hydroxide comprises $Mg(OH)_2$.

51. (Withdrawn) The method according to claim 50 where said second reaction proceeds according to a reaction mechanism of $NaBH_4 + 2\ Mg(OH)_2 \rightarrow NaBO_2 + 2MgO + 4H_2$.

52. (Withdrawn) The method according to claim 1 where said hydride comprises $NaBH_4$ and said hydroxide comprises NaOH.

53. (Withdrawn) The method according to Claim 52 where said second reaction proceeds according to a reaction mechanism of $NaBH_4 + 4NaOH \rightarrow NaBO_2 + 2Na_2O + 4H_2$.

54. (Original) The method according to claim 1 wherein at least a portion of said water is provided in the form of a hydrated hydroxide compound.

55. (Original) The method according to claim 54 wherein said hydrated hydroxide compound is selected from the group consisting of: hydrated lithium hydroxide ($LiOH{\cdot}H_2O$), hydrated sodium hydroxide ($NaOH{\cdot}H_2O$), hydrated potassium hydroxide ($KOH{\cdot}H_2O$), hydrated barium hydroxide ($Ba(OH)_2{\cdot}3H_2O$), hydrated barium hydroxide ($Ba(OH)_2{\cdot}H_2O$), hydrated lithium aluminum hydroxide ($LiAl_2(OH)_7{\cdot}2H_2O$), hydrated magnesium aluminum hydride ($Mg_6Al_2(OH)_{18}{\cdot}4H_2O$), and mixtures thereof.

56. (Withdrawn) The method according to claim 54 wherein said hydride comprises MgH_2 and said hydroxide comprises $LiOH{\cdot}H_2O$.

57. (Original) The method according to claim 54 wherein said hydride comprises LiH and said hydroxide comprises $LiOH{\cdot}H_2O$.

58. (Withdrawn) The method according to claim 54 wherein said hydride comprises NaH and said hydroxide comprises $LiOH{\cdot}H_2O$.

59. (Withdrawn) The method according to claim 54 wherein said hydride comprises LiH and said hydroxide comprises $NaOH \cdot H_2O$.

60. (Withdrawn) The method according to claim 54 wherein said hydride comprises NaH and said hydroxide comprises $NaOH \cdot H_2O$.

61. (Original) The method according to claim 54 wherein said hydride comprises $LiBH_4$ and said hydroxide comprises $LiOH \cdot H_2O$.

62. (Withdrawn) The method according to claim 54 wherein said hydride comprises $NaBH_4$ and said hydroxide comprises $NaOH \cdot H_2O$.

63. (Original) The method according to claim 54 where in said hydroxide comprises a non-hydrated hydroxide compound and a hydrated hydroxide compound.

64. (Original) The method according to claim 63 where said hydride comprises $LiBH_4$ and said hydroxide comprises LiOH and $LiOH \cdot H_2O$.

65. (Original) The method according to claim 63 where said reaction proceeds according to a reaction mechanism of $LiBH_4 + LiOH + LiOH \cdot H_2O \rightarrow Li_3BO_3 + 2\ Li_2O + 4H_2$.

66. (Original) The method according to claim 63 where said reaction proceeds according to a reaction mechanism of $2\ LiBH_4 + LiOH + 2\ LiOH \cdot H_2O \rightarrow Li_4B_2O_5 + LiH + 7\ H_2$.

67. (Previously Presented) A method of producing hydrogen comprising:
generating heat in a first reaction by reacting water with a portion of particles of a hydride present in a first material composition, wherein said heat is used in a second reaction; and
reacting in the solid-state another portion of particles of said hydride present in said first material composition which are mixed with particles of a hydroxide present in a second material composition in said second reaction, thereby forming hydrogen gas and a byproduct composition comprising an oxide.

68. (Original) The method according to claim 67 wherein said second reaction commences while said first reaction is occurring.

69. (Original) The method according to claim 67 wherein said heat provides an activation energy sufficient to commence said second reaction.

70. (Original) The method according to claim 67 wherein said second reaction is exothermic.

71. (Original) The method according to claim 67 wherein said second reaction is endothermic.

72. (Currently Amended) A hydrogen storage composition having a hydrogenated state and a dehydrogenated state:

(a) in said hydrogenated state, said composition comprises a mixture of particles of a hydride and a hydrated hydroxide, the quantity of the hydride being sufficient to react with ~~substantially chemically equivalent to~~ the water content and hydroxide content of the hydrated hydroxide for a solid-state reaction to produce hydrogen gas and an oxide; and

(b) in said dehydrogenated state, said composition comprises the oxide.

73. (Original) The composition of claim 72 wherein said hydride is represented by the formula MI^xH_x, where MI represents one or more cationic species other than hydrogen, and x is an average valence state of MI.

74. (Original) The composition of claim 72 wherein said hydrated hydroxide is represented by the formula $MII^y(OH)_y \cdot wH_2O$, where MII represents one or more cationic species other than hydrogen, y is an average valence state of MII, and w represents the stoichiometric ratio of water in said hydrated hydroxide.

75. (Original) The composition of claim 72 wherein said hydride is represented by $MI^{x}H_{x}$ and said hydrated hydroxide is represented by $MII^{y}(OH)_{y}\cdot wH_{2}O$, where MI and MII respectively represent said one or more cationic species other than hydrogen, x and y represent average valence states of MI and MII, respectively, and w represents the stoichiometric ratio of water in said hydrated hydroxide.

76. (Original) The composition of claim 72 wherein said hydride is represented by $MI^{x}H_{x}$ and said hydrated hydroxide is represented by $MII^{y}(OH)_{y}\cdot wH_{2}O$, where MII represents said one or more cationic species other than hydrogen, y represents an average valence state of MII, and w represents a stoichiometric amount of hydrated water.

77. (Original) The composition of claim 76 wherein MI is selected from the group consisting of Al, As, B, Ba, Be, Ca, Cd, Ce, Cs, Cu, Eu, Fe, Ga, Gd, Ge, Hf, Hg, In, K, La, Li, Mg, Mn, Na, Nd, Ni, Pb, Pr, Rb, Sb, Sc, Se, Si, Sm, Sn, Sr, Th, Ti, TI, V, W, Y, Yb, Zn, Zr, and mixtures thereof.

78. (Original) The composition of claim 76 wherein MII is selected from the group consisting of Al, As, B, Ba, Be, Ca, Cd, Ce, Cs, Cu, Eu, Fe, Ga, Gd, Ge, Hf, Hg, In, K, La, Li, Mg, Mn, Na, Nd, Ni, Pb, Pr, Rb, Sb, Sc, Se, Si, Sm, Sn, Sr, Th, Ti, TI, V, W, Y, Yb, Zn, Zr, and mixtures thereof.

79. (Original) The composition of claim 76 wherein MI and MII are each elements independently selected from the group consisting of Al, B, Ba, Be, Ca, Cs, K, Li, Mg, Na, Rb, Si, Sr, Ti, V and mixtures thereof.

80. (Original) The composition of claim 76 wherein MI and MII are each elements independently selected from the group consisting of Al, B, Be, Ca, K, Li, Mg, Na, Sr, Ti, and mixtures thereof.

81. (Original) The composition according to claim 72 wherein said hydrated hydroxide is selected from the group consisting: hydrated lithium hydroxide ($LiOH\cdot H_{2}O$),

hydrated sodium hydroxide ($NaOH \cdot H_2O$), hydrated potassium hydroxide ($KOH \cdot H_2O$), hydrated barium hydroxide ($Ba(OH)_2 \cdot 3H_2O$), hydrated barium hydroxide ($Ba(OH)_2 \cdot H_2O$), hydrated lithium aluminum hydroxide ($LiAl_2(OH)_7 \cdot 2H_2O$), hydrated magnesium aluminum hydride ($Mg_6Al_2(OH)_{18} \cdot 4H_2O$), and mixtures thereof.

82. (Original) The composition of claim 72 wherein said hydride is selected from the group consisting of: lithium hydride (LiH), sodium hydride (NaH), potassium hydride (KH), beryllium hydride (BeH_2), magnesium hydride (MgH_2), calcium hydride (CaH_2), strontium hydride (SrH_2), titanium hydride (TiH_2), aluminum hydride (AlH_3), boron hydride (BH_3), lithium borohydride ($LiBH_4$), sodium borohydride ($NaBH_4$), magnesium borohydride ($Mg(BH_4)_2$), calcium borohydride ($Ca(BH_4)_2$), lithium alanate ($LiAlH_4$), sodium alanate ($NaAlH_4$), magnesium alanate ($Mg(AlH_4)_2$), calcium alanate ($Ca(AlH_4)_2$), and mixtures thereof.

83. (Withdrawn) The composition of claim 72 wherein said hydride comprises MgH_2 and said hydrated hydroxide comprises $LiOH \cdot H_2O$.

84. (Original) The composition of claim 72 wherein said hydride comprises LiH and said hydrated hydroxide comprises $LiOH \cdot H_2O$.

85. (Original) The composition of claim 72 wherein said hydride comprises NaH and said hydrated hydroxide comprises $LiOH \cdot H_2O$.

86. (Original) The composition of claim 72 wherein said hydride comprises LiH and said hydrated hydroxide comprises $NaOH \cdot H_2O$.

87. (Original) The composition of claim 72 wherein said hydride comprises NaH and said hydrated hydroxide comprises $NaOH \cdot H_2O$.

88. (Original) The composition of claim 72 wherein said hydride comprises $LiBH_4$ and said hydrated hydroxide comprises $LiOH \cdot H_2O$.

89. (Withdrawn) The composition of claim 72 wherein said hydride comprises $NaBH_4$ and said hydrated hydroxide comprises $NaOH \cdot H_2O$.